Energy Commission Staff Distributed Energy Resources Training Seminar

Technologies

California Energy Commission, Sacramento

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Distributed Energy Resources (DER) Training Seminar

- Welcome
- Introductions
- Morning Session
  - Overview/History/Definitions
  - Distributed Energy Resources Technologies Characteristics and Applications

Overview

- Feb. 26 request from CPUC staff
- Purpose: Provide technical background to support CPUC Rulemaking 98-12-015
- Feb. 22, 1999 Assigned Commissioner's Ruling
  - Cost, current and projected status assumptions
- Let's keep this interactive and informal

History

- First major conference sponsored by EPRI, NREL and PG&E in 1992
  - Benefits were hypothesized; few installations at that time
  - Emphasis was on utility perspective
- April 25-26, 1996: DG Roundtable sponsored by Energy Commission
  - Public/private partnership to analyze barriers and develop blueprint for action
  - www.energy.ca.gov/CADER/documents/CADER_exec_summ.html

- Outgrowth of DG Roundtable was concept for California Alliance for Distributed Energy Resources (CADER)
- CADER focuses on identifying barriers, developing recommendations, and implementing solutions
  - Interconnection
  - Market Assessment and Technology Characterization
  - Communications
  - Regulatory and Legislative

Definitions

- Distributed Generation (DG) -- CPUC
- Distributed Energy Resources (DER) -- California Alliance for Distributed Energy Resources -- CADER
- Distributed Utility (DU) - - Distributed Utility Associates

CPUC OIR Definition of DG

- "Generation, storage, or DSM devices, measures and/or technologies that are connected to or injected into the distribution level of the T&D grid."
- Located at customer's premises on either side of meter
- Located at other points in distribution system, such as utility substation

CADER Definition of Distributed Energy Resources (DER)

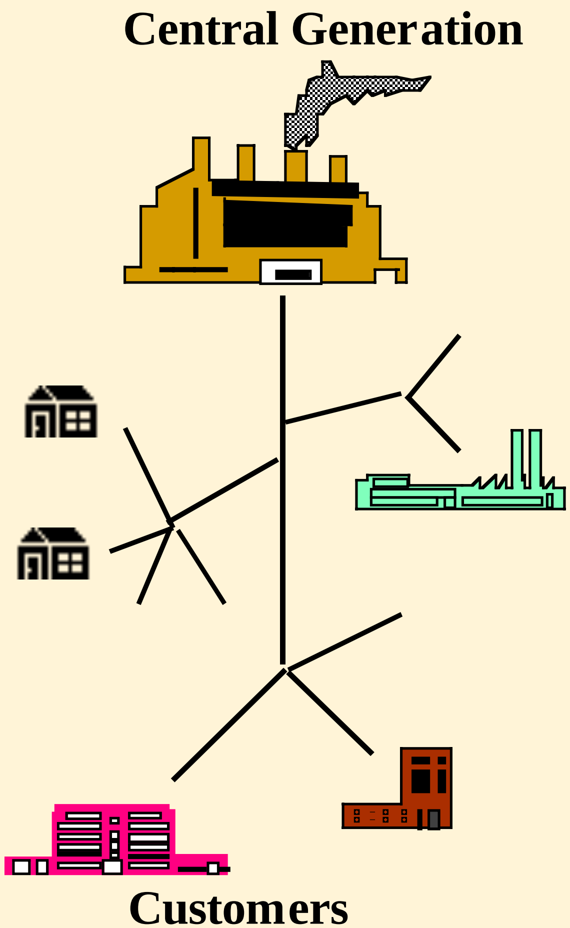
- Generates or stores electricity
- Located at or near a load center
- May be grid-connected or isolated
- Has a greater value than grid power:
  - Customer value
  - Distribution system benefits
  - Back-up or emergency power
  - Social or environmental value

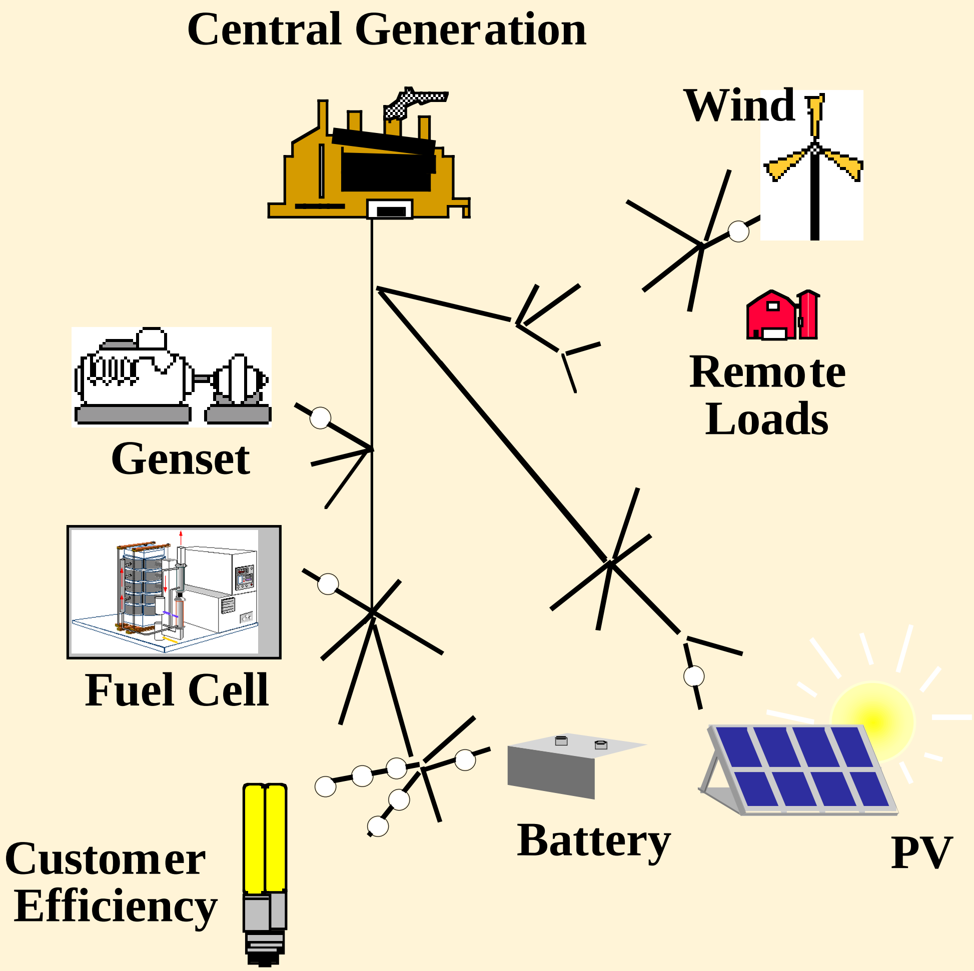
Distributed Utility Definition

A Distributed Utility incorporates energy-significant distributed generation, storage and feeder-specific DSM/CEE in its T&D system to augment central station plants and optimizes T&D asset utilization.

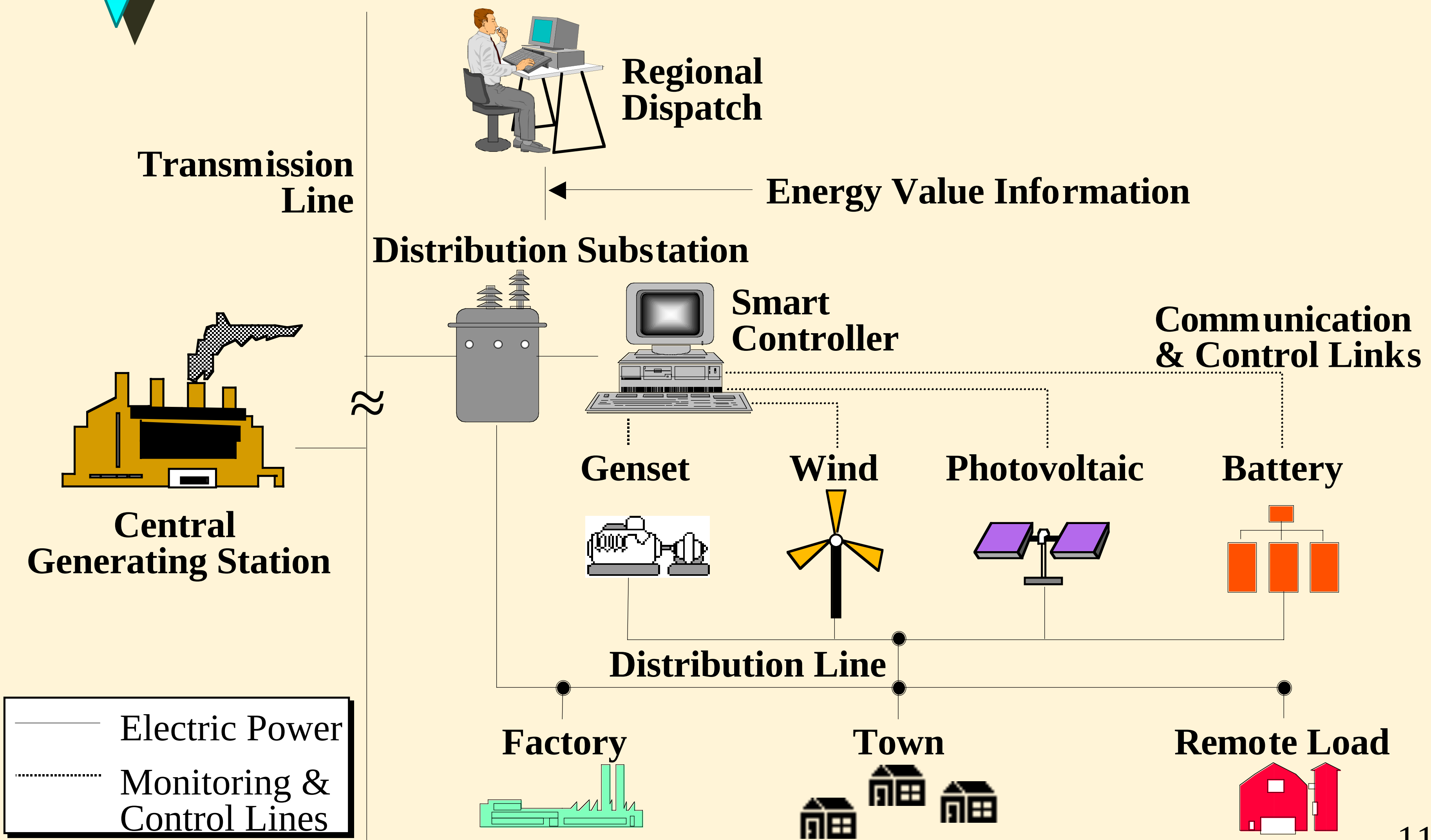
Today's Central Utility

Tomorrow's Distributed Utility?





Operating The Distributed Utility



DU Nodes in an Electric Utility

Utility System **5000 MW**

Distribution Planning Areas
150 MW

Distribution Substations
50 MW

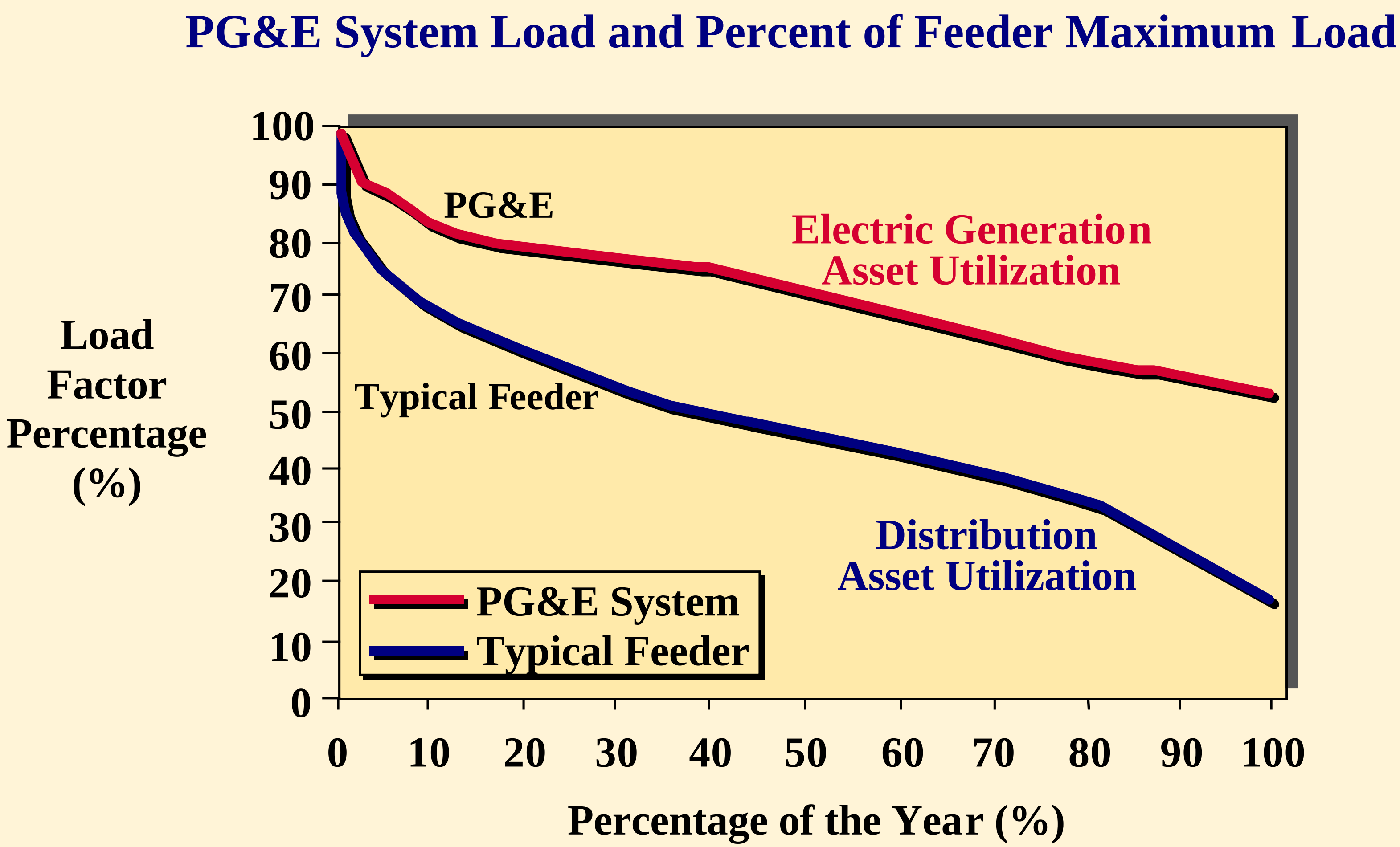
Distribution Feeders
10 MW

Customers

1/3 Industrial	1/3 Commercial	1/3 Residential
1 MW	100 kW	5 kW

The Distributed Utility Opportunity:

Improved Asset Utilization



Characteristics and Applications of Distributed Energy Resources Technologies

Presented by:

Pramod Kulkarni

Energy Technologies Division

Overview

- Define distributed energy resources (DER) technologies
- List potential DER technologies
- Present characteristics, attributes and impacts
- Understand DER role in deregulated market
- Discuss cost and deployment issues

Why Learn About DER Technologies?

- DG/DER facilitate competition and expand consumer choice
- Provide services in an unbundled electric service
- Technology characteristics have a bearing on one level and nature of competition on the distribution grid.
- Rulemaking deployment: easy for one technology and could be detrimental to another
- Rule benefiting one customer class may not be best for another using the same technology

Issues Relevant for Rulemaking Affected by Technological Attributes

- Impact on the safety and grid reliability
- Reduced use of grid (non-recovered cost)
- Degree of back-up support required from the distribution grid
- Dispatchability
- Determine the benefits of distributed generation to the grid (value)
- Require advanced communications and metering for dispatch and control

Technologies

- Fossil-fuel based distributed generation
- Non-fossil fuel based generation
- Storage technologies

What Is Different About DER Technologies

- Some technologies are old and deployed differently
  - Internal-combustion engines
  - Gas turbines
  - Fuel cells
  - Batteries

What is Different About DG/DER Technologies

- Recent technologies are tailored for DG/DER markets
  - Small wind systems
  - Small fuel cells (proton exchange membrane)
  - Photovoltaic (PV shingles, AC modules)
  - Storage technologies (flywheels, SMES)
  - Micro-turbines

Common Traits in DG/DER Technologies

- Mass produced
- Modular
- Small (<20 MW)
- Support system reliability
- Provide economic advantage to end-user, ESP, and/or UDC
- Provide customer and UDCs an alternative to standard generation options

What are Distributed Energy Resources?

- Technologies installed by customers, energy service providers (ESP) or a utility distribution company (UDC) at or near a load for an economic advantage over the distribution grid-based option.

CADER's Definition of Distributed Energy Resources

- Generates or stores electricity
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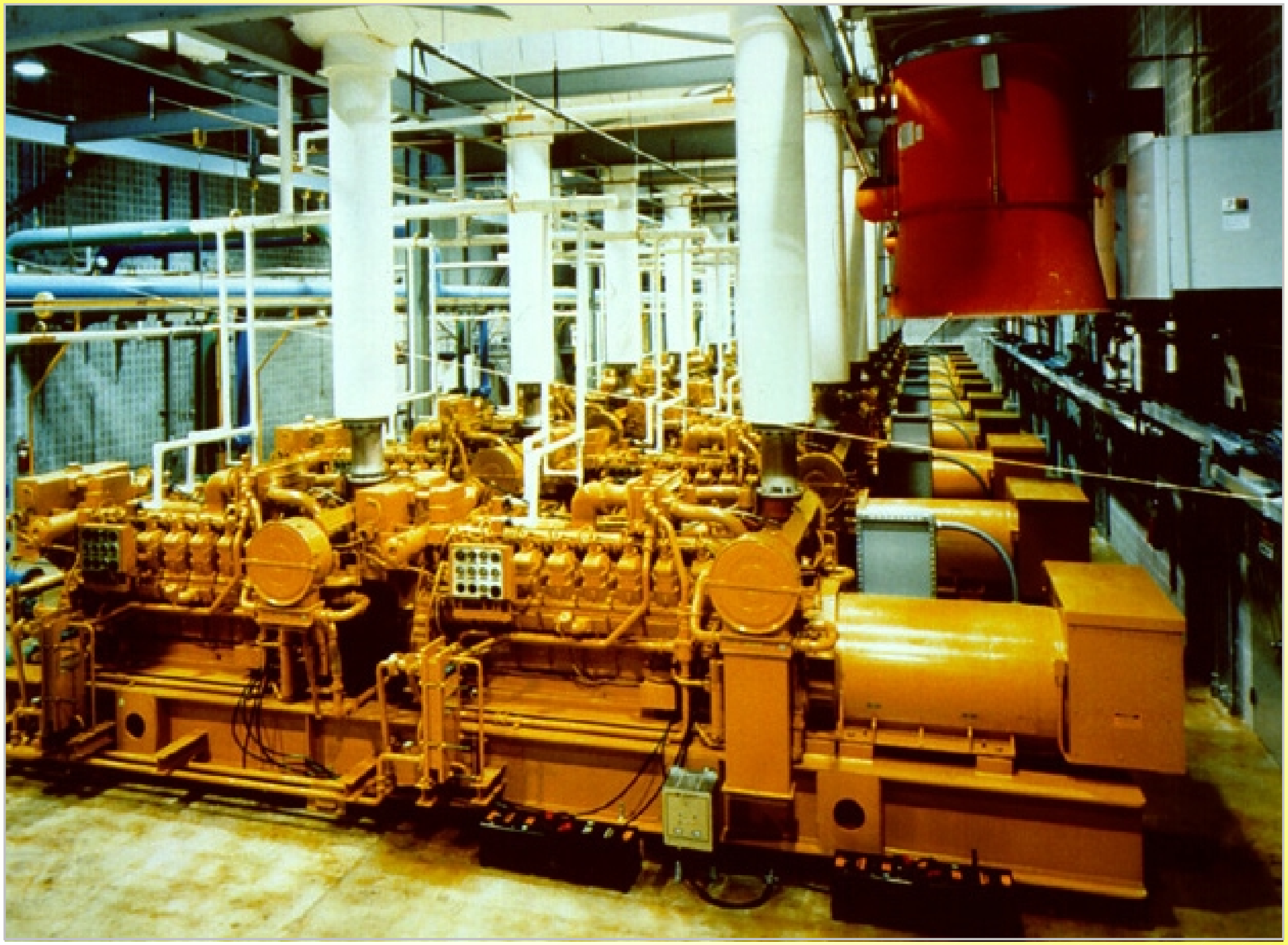
Economic Advantage From DG/DER Systems

- Economic advantages included one or more of the following:
  - Load management
  - Reliability
  - Power quality
  - Fuel flexibility
  - Cogeneration
  - Deferred or reduced T&D investment or charge
  - Increased distribution grid reliability/stability

Fossil Fuel Technologies

- Internal-combustion engines
  - Diesel engines
  - Natural gas engines
- Micro-turbines
- Fuel cells
- Stirling engines

Photo courtesy of Caterpillar



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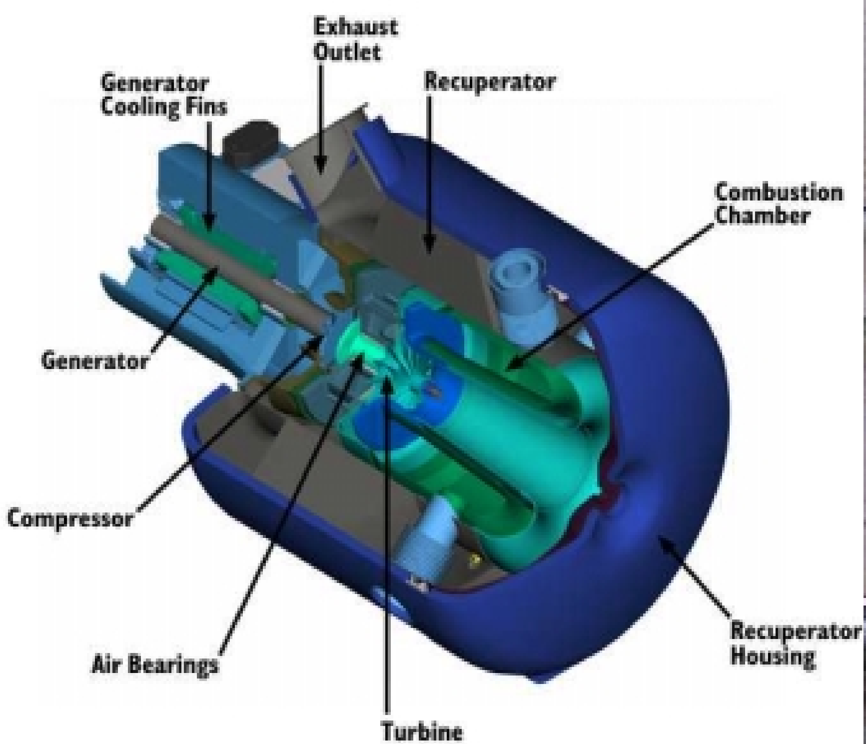


Diagram above courtesy of Capstone.

Photo on right courtesy of Bowman.

Commercial Status of DG/DER

	IC Engines	Small Turbines	Micro-turbines	Fuel Cell
Commercial Availability	Well established	Well established	New industry	Well established
Size	50 kW- 5 MW	1 MW – 50 MW	25 kW – 75 kW	1 kW – 200 kW
Installed Cost ($/kW)	$800 – $1500	$700 – $900	$500 – $1300	$3000
O&M Costs (cents/kWh)	0.7 – 1.5	0.2 – 0.8	0.2 – 1.0	0.3 – 1.5
Fuel Type	Diesel, propane, NG, oil & biogas	Propane, NG, distillate oil & biogas	Propane, NG, distillate & biogas	Hydrogen, biogas & propane
Typical Duty Cycles	Baseload	Baseload, intermed. peaking	Peaking Intermed. Baseload	Baseload

Benefits of Fossil-Fuel Based Distributed Generation

- Dispatchable
- Can be used for baseload or peaking
- Reliable
- Used on either side of meter
- Fuel easily available
- First to be deployed

Deployment Issues of Fossil-Fuel Based Distributed Generation

- Air and noise emissions (except fuel cell)
- Islanding
- Interconnection standards
- Reduced use of distribution system
- May need upgrading of fuel supply system (e.g gas pressure)

Renewable Energy Technologies

- Photovoltaics
- Solar-dish Stirling
- Small wind systems
- Large wind systems
- Stirling engines (biomass, LFG)

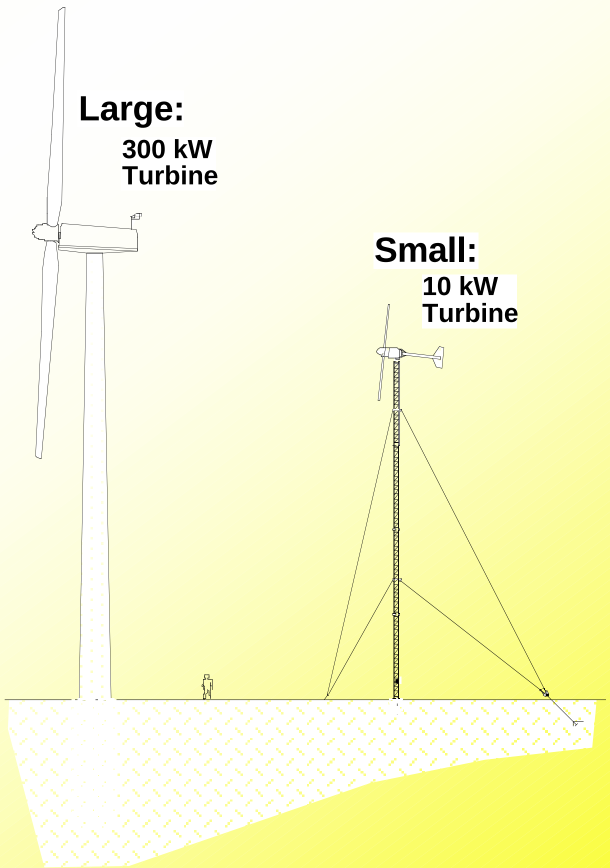
Photo courtesy of Edison Technology Solutions

Photo courtesy of Edison Technology Solutions

Photo courtesy of Edison Technology Solutions

Small Wind Turbines are Different

- **Large Turbines (300-750 kW)**
  - **Installed in “Windfarm” Arrays Totaling 1 - 100 MW**
  - **$1,000/kW; Designed for Low Cost of Energy**
  - **Requires 6 m/s (13 mph) Average Sites**
- **Small Turbines (0.3-50 kW)**
  - **Installed in “Rural Residential” On-Grid and Off-Grid Applications**
  - **$2,500-5,000/kW; Designed for Reliability / Low Maintenance**
  - **Requires 4 m/s (9 mph) Average Sites**

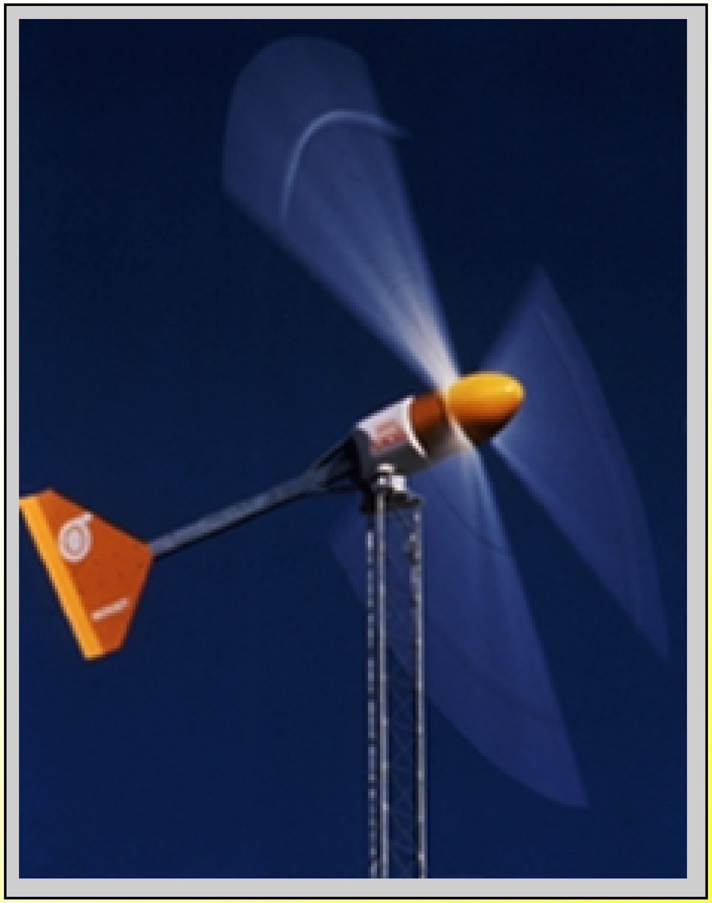


Modern Small Wind Turbines:

High Tech, High Reliability, Low Maintenance

- Aerospace Technology
- High Reliability - Low Maintenance
- Easily Retrofits to Homes & Businesses
- Typical Costs: $ 3 / Watt (AC, Installed)
- O&M Costs ~ $0.005/kWh
- American Companies Lead in Technology and Market Share
- Further Advances Coming - DOE Advanced Small Wind Turbine Program: 4 Projects, 8 - 40 kW

10 kW Bergey Turbine



Commercial Status of DG/DER

	Photovoltaic	Dish-Stirling	Small Wind	Large Wind
Commercial Availability	Well established	Year 2000?	Well established	Well established
Size	0.30 kW – 2 MW	30 kW and larger	600 watts – 40 kW	40 kW – 1.5 MW
Installed Cost ($/kW)	$6,000 – $10,000	$10,000/ kW (now) $400/kW (later)		$900 – $1,100
O&M Costs (cents/kWh)	Minimal		Varies	1.0
Fuel Type	Solar	Solar and NG (hybrid mode)	Wind	Wind
Typical Duty Cycles	Peaking	Peaking or Interm. Hybrid mode	Varies	Varies

Benefits of Renewable Based Distributed Generation

- No/low noise or air pollution
- Independent of fossil fuel price changes
- Good for very small, modular applications
- Could be used on either side of a meter
- Coincident with peak demand when solar resource is used

Deployment Issues of Renewable Based Distributed Generation

- Intermittent availability (unless used with storage)
- Islanding
- Less than 2 MW (100 kW or Less)
- Interconnection standards and cost
- Will need grid support
- New industry, lacks public exposure

Storage Technologies

- Batteries
- Modular pumped hydro
- Superconducting magnetic energy storage (SMES)
- Flywheels
- Ultracapacitors

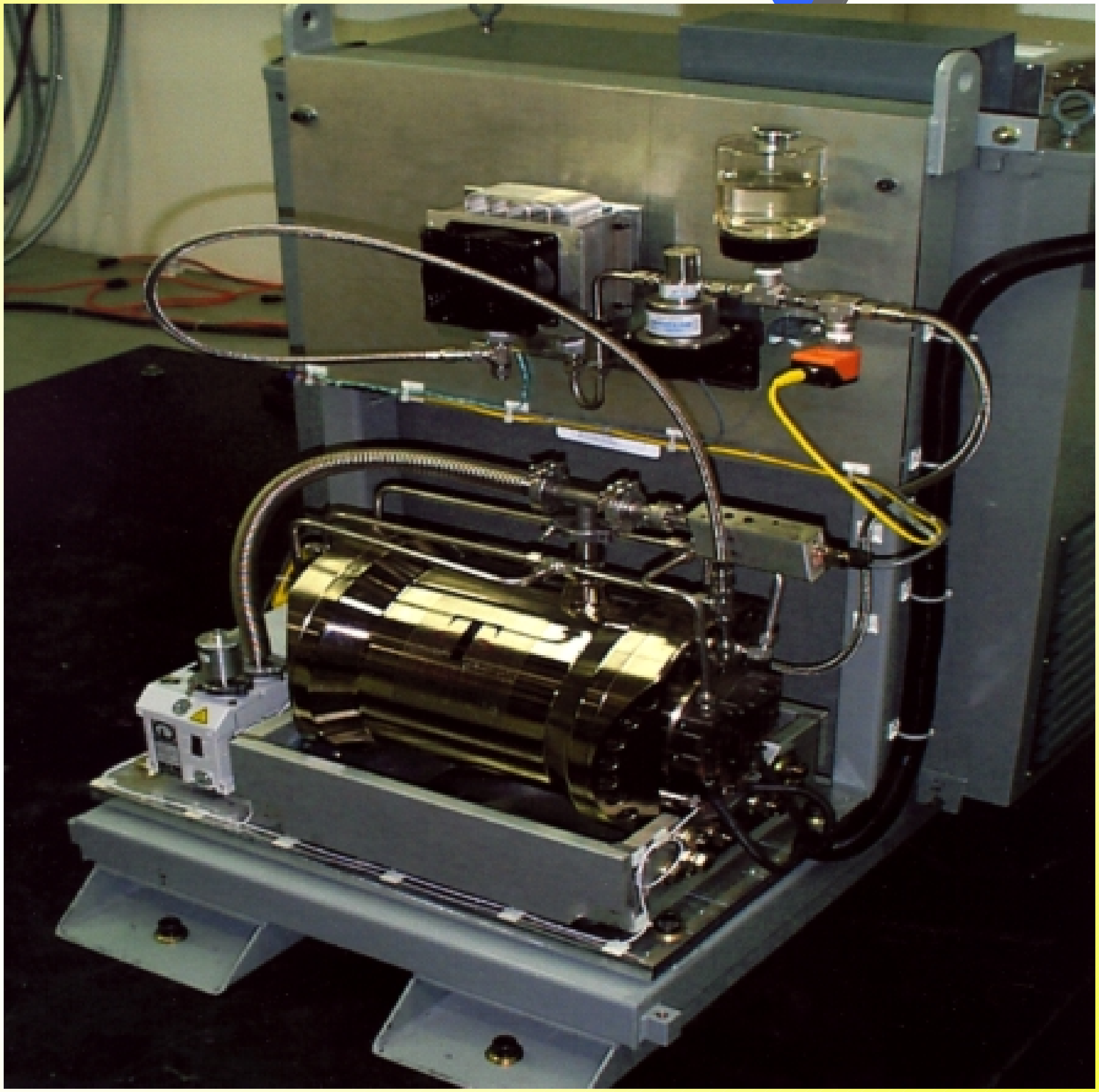


Photo courtesy of
Trinity Flywheel, Inc.

Cryostat Assembly

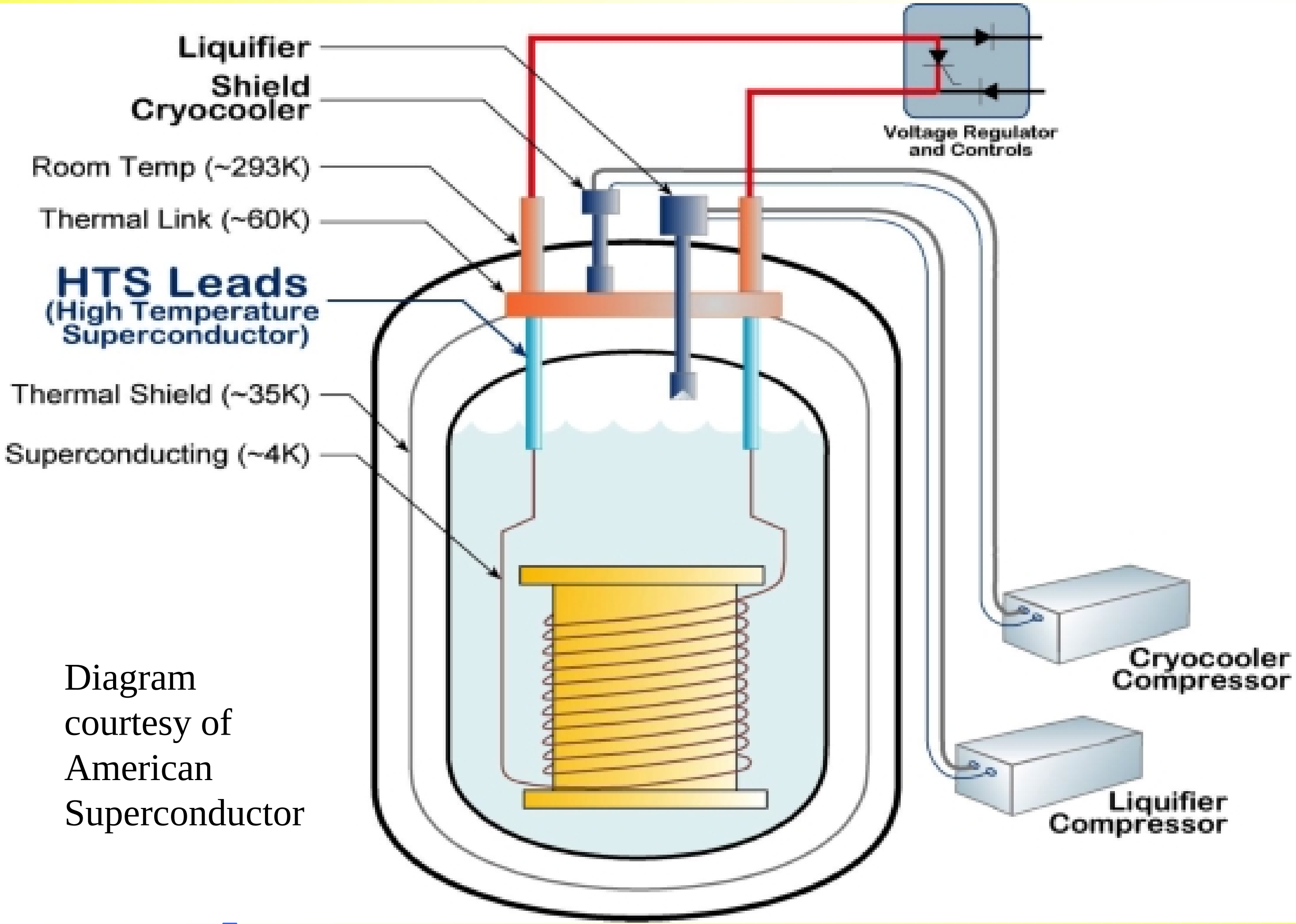
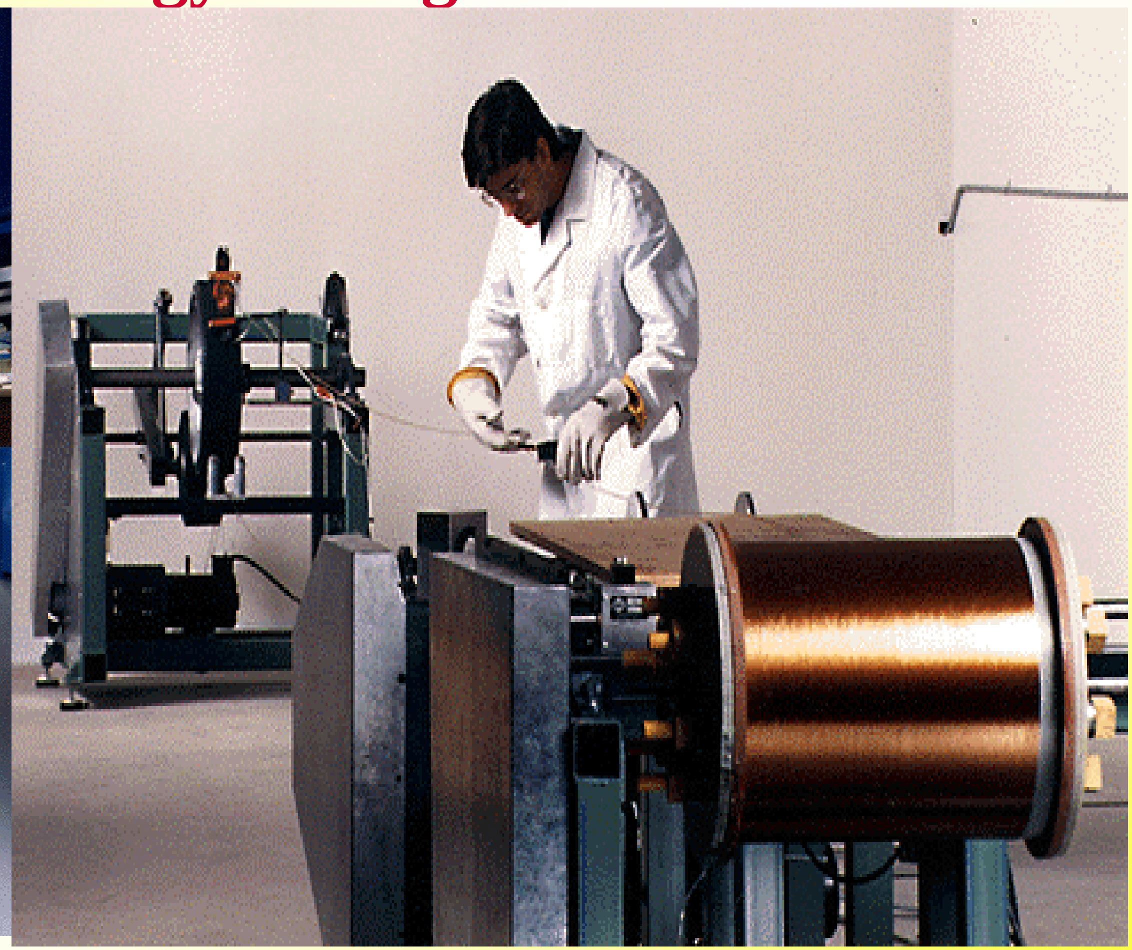


Diagram courtesy of American Superconductor

Superconducting Magnet Provides Compact Energy Storage



Photos courtesy of American Superconductor

PQ AC Installed at Fairbluff, NC

Photo courtesy of American Superconductor

Storage Provides Solutions to Power Quality Problems

	Transients	Voltage Disturbance	Interrup-tion	Harmonic Distortion	Voltage Flicker
Energy Storage	X	X	X	X	X
Surge Arrestor	X			X	
Filter	X			X	
Isolation Transformer	X				
Constant Voltage Transfomer		X			
Dynamic Voltage Restorer		X			
Back-up Generator			X		

Benefits of Storage Technologies

- Multiple Uses:
  - Load management
  - Power quality
  - Dispatchability
  - Uninterrupted power supply
  - Reliability/Availability
  - Dynamic benefits for the grid

Storage As a Distributed Energy Resource

- Storage type and size varies
- Determining factors include:
  - Purpose of use
  - Duration of use
  - Comparative cost

Benefits of Storage Technology as a Distributed Energy Resource (cont'd)

- Provide auxiliary services on either side of the meter
- Used by UDC, ESP, ESCo and end-user
- Wide range of size and storage duration
- Costs will come down faster as core technologies are used for transportation
- Batteries and SMES available now

Impact of DG/DER Technology Deployment

- Empower customers by providing a choice
- Provide missing or expensive components of an unbundled electrical service
- Allow feed-back of electricity to grid
- Create safety concerns, real or perceived, for UDC
- Provide dynamic benefits to the distribution system
- Positive or adverse impact on the T&D System

Most Likely Users of DG in Next Five Years

	IC Engines	Small and micro turbines	Storage	Fuel Cell	PV	Small Wind	Large wind
Indust.	X	X	X	X			
Comm.	X	X	X	X	X	X	
Resi-dential				X	X	X	
UDC		X	X	X	X		X

Differences in Technical Attributes That Require Attention in Rulemaking

Summary of Technical Attributes

	Engine Genset	Turbine Genset	Battery	Fuel Cells	PV	Dish-Stirling
Conventional Interface	●	●				●
Electronic Interface			●	●	●	
Dispatchability	●	●	● [1]	●		● [2]
Load Following	●	●	●	●		
Intermittency					●	●
Peaking Generation	●	●	●	●	●	●
Base Load				●		
Intermediate Duty		●		●		● [2]

Note:
1. When charged.
2. With supplement heat from natural gas burner.

(Source: NREL)

Auxiliary Technologies Essential for Integration of DER to the Grid

- Power electronics and power conditioners
  - Improve power quality
  - Safety
- Control, metering and communications
  - Dispatch
  - Billing
  - Safety
- Planning and valuation tools
  - Value to grid
  - Capacity needs assessment

Technology Mix Affects Grid Impacts

- Source of capacity on the grid affects safety,backup and cost
  - 5 MW diesel-generation capacity delivers more kWh and is dispatchable compared to 5 MW of PV
  - 5MW diesel adds more pollution than 5 MW fuel cells
  - 5MW of a natural gas engine provides baseload power with little or no backup, but 5 MW of wind requires backup

Next Steps for Assessing Impact of Various Technologies

- Better understand impact of DG/DER systems on the grid through site monitoring
- Demonstrate new DG/DER systems
- Valuation of DG/DER for system reliability and support